PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/24 | A1

(11) International Publication Number: WO 98/56198

(43) International Publication Date: 10 December 1998 (10.12.98)

(21) International Application Number: PCT/US98/11480

(22) International Filing Date: 4 June 1998 (04.06.98)

(30) Priority Data:
08/871,007 6 June 1997 (06.06.97) US

(71) Applicant *(for all designated States except US)*: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 S. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: HANLEY, Donald, V. [CA/US]; 4818 N. Meadow Ridge Circle, McKinney, TX 75070 (US).

(74) Agent: BOLVIN, Kenneth, W.; Northern Telecom Limited, Patent Dept., P.O. Box 832130, Richardson, TX 75083-2130 (US).

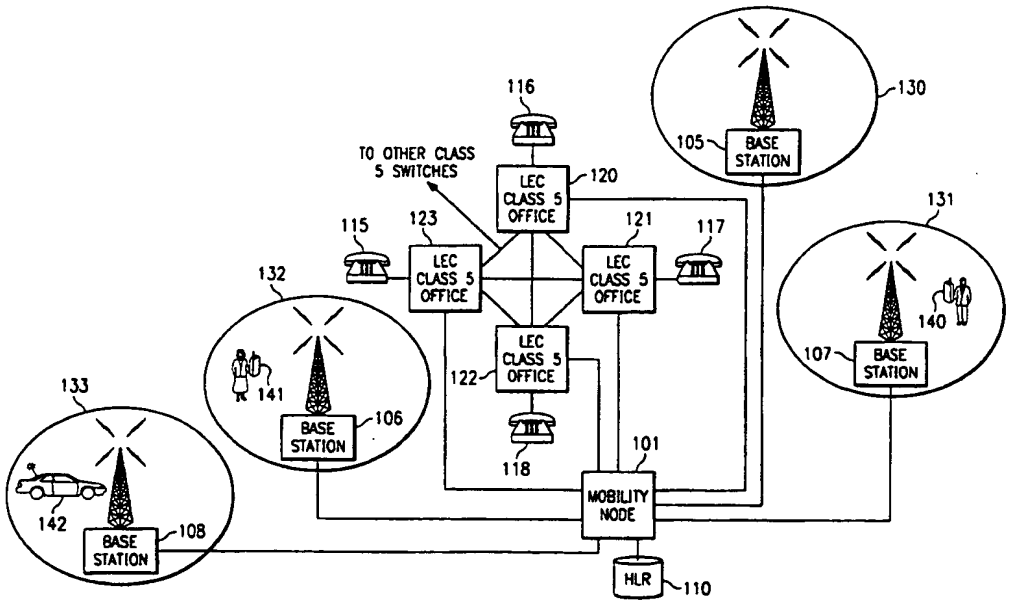
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: WIRELESS ACCESS FOR LOCAL EXCHANGE CARRIERS



(57) Abstract

The Mobility Node (101) of the present invention maps signals, dialed digits, or other information from the mobile (140–142) to the appropriate protocols of the local exchange carrier's (LEC) Class 5 switch (120–123) and vice versa. If the signal does not have an LEC or base station equivalent, the Mobility Node (101) performs the appropriate processing. Multiple Mobility Nodes (101) are connected by a predetermined protocol link to enable inter-system communication.

WIRELESS ACCESS FOR LOCAL EXCHANGE CARRIERS

BACKGROUND OF THE INVENTION

I. FIELD OF THE INVENTION

The present invention relates to radio communications. More particularly, the present invention relates to wireless access to a local exchange carrier network.

II. DESCRIPTION OF THE RELATED ART

The availability of personal communication services (PCS) in the 1.9 GHz band is a growing segment of the wireless market. PCS is a boon to the holders of the bandwidth licenses. The wireline (local exchange carriers) and cellular operators, however, face losing subscribers because of this new technology.

The average subscriber is not likely to know or care about the subtle technology differences between cellular and PCS. It is generally expected that the cellular operators will retain the high-speed, high-mobility subscribers while the PCS operators are more likely to gain the low-speed, low-mobility subscribers.

The local exchange carriers (LECs) are at a severe disadvantage due to their extremely large and expensive telephony infrastructure that is mobility-incapable. Mobility has been shown to be of high value to customers even though, most of the time, they need only basic voice services.

There are currently a number of options that provide subscribers wireless access to wireline services. These options include wireless local loop, cellular/PCS overlay, and Generic-C. These technologies all provide some level of mobility but also have some limitations.

Wireless local loop, with the in-building equivalent Wireless Adjunct, are designed to replace the last few yards of copper wire to the subscriber's telephone with a radio link. Various wireless local loop solutions employ a variety of RF technologies, but their general characteristics are similar: they appear to the host LEC office as a set of subscriber lines and convert the signaling transmitted over the RF interface into the signaling required by the LEC and vice versa. A wireless local loop solution is little more than a protocol converter for wireless telephones.

The present invention encompasses a wireless access system that enables a local exchange carrier to provide wireless access to subscribers while also providing the benefits of wireline services. The present invention thus provides the benefits of both a cellular or PCS system and a wireline system.

The system of the present invention is comprised of a plurality of cells. Each cell has a base station that is coupled to an antenna for communicating with the mobile radiotelephones within that cell.

A plurality of local exchange carrier (LEC) Class 5 switches are coupled to wireline subscriber units. Additionally, each switch has a plurality of input/output ports, a port being assigned to each radiotelephone that is operating in the system.

A Mobility Node is coupled to the input/output ports on the LEC switches, the cells, and a subscriber database. The subscriber database has a listing of the wireless subscribers registered to operate in that particular system.

The Mobility Node makes the wireless mobiles appear as wireline units to the LECs. This is accomplished by the Mobility Node mapping signals received from the LEC switches to the appropriate radio frequency (RF) protocol for the base station. The Mobility Node also maps signals from the base stations to the appropriate LEC protocol for the LEC switches.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of the wireless system of the present invention.

FIG. 2 shows a flowchart of a wireless access process of the present invention for making a call from a local exchange carrier.

FIG. 3 shows a flowchart of a wireless access process of the present invention for making a call from a wireless mobile.

FIG. 4 shows a flowchart of a wireless access process of the present invention for performing a hand-off of a wireless mobile.

FIG. 5 shows a flowchart of a wireless access process of the present invention in which a roaming wireless mobile registers with a visited system.

FIG. 6 shows a block diagram of a wireless system utilizing some components of the system illustrated in FIG. 1.

Access (TDMA), Global System for Mobile communications (GSM), and other cellular radiotelephone systems.

The cell, in the preferred embodiment, is sectorized. As is well known in the art, this is accomplished by using a number of directional antennas, one directional antenna for each sector, in the approximate center of the cell. An alternate embodiment uses one omnidirectional antenna in the center of the cell to radiate the entire cell.

The antennas are each coupled to a base station (105-108) that is comprised of radio transmitters and receivers. The transmitters and receivers are tuned to the various frequencies allotted for that particular cell in a particular metropolitan system.

A Mobility Node (101) couples the base stations (105-108) to the LEC office switches (120-123). The Mobility Node (101) is similar to a mobile telephone switch that has a processor for handling multiple functions for the base stations including hand-offs and roaming of the radiotelephone.

The Mobility Node (101) of the present invention, however, is capable of advanced features beyond a prior art mobile telephone switch. The Mobility Node (101) also maps wireless protocols to Class 5 switch protocols, thereby making the wireless mobile appear as a wireline telephone to the LEC.

The Mobility Node (101) is coupled to a database referred to as the home location register (HLR) (110). This database keeps track of the wireless subscribers who are registered to operate in the system. This database stores data on the subscriber such as the subscriber's telephone number and the LEC input/output port with which the telephone number is associated.

In the subsequent discussion, the Mobility Node may be referred to either as a home Mobility Node or a visited Mobility Node. The home Mobility Node is associated with the system in which the wireless mobile appears in the system's home location register (HLR). The visited Mobility Node is associated with a system in which the wireless mobile is roaming and therefore is not resident in that system's HLR.

The processes of the present invention are illustrated in FIGs. 2-5, 7, and 8. The following descriptions of these processes refer to the block diagram of FIG. 6.

that port *b* of the LEC (610) has been seized (step 210). The Mobility Node (605) then queries the HLR (606) to determine which mobile is associated with that particular port (step 215). If the HLR (606) does not respond (step 220), an error condition exists since the Mobility Node (605) does not know which mobile to page. The Mobility Node then provides an appropriate treatment (step 225) such as a tone or announcement indicating the error condition.

If the HLR (606) responds to the query (step 220), it then must be determined if the mobile is roaming away from the home system (step 230). If the subscriber is not roaming, the home Mobility Node (605) pages the cells (601 and 602) (step 240) and waits for a response (step 245) from the mobile (630). In the preferred embodiment, this response is the same as the response generated by a mobile unit in an AMPS system. Alternate embodiments use other types of responses.

If the mobile (630) does not respond to the page request (step 245), the call is treated as being unanswered (step 260). If the mobile (630) recognizes the page request from the cell (602) and responds (step 245), the home Mobility Node (605) receives the response and performs its normal call setup tasks that includes assigning the mobile (630) to an available channel on the cell (602) and connecting the assigned channel to port *b* (step 250). The home Mobility Node (605) then causes the mobile unit (630) to ring by transmitting an alert command (step 255) to the mobile.

At this point, the mobile subscriber (630) and the calling subscriber (615) are connected and the process goes to the active call process (step 700) illustrated in FIG. 7. If the mobile (630) answers the call or invokes any special services or vertical features (such as conference calls or call waiting), the home Mobility Node (605) transmits the mobile's signals, dialed digits, or other information to the LEC office (610) using the appropriate LEC protocols, making the mobile appear to behave as a wireline unit. These protocols include those well known in the art such as TR303, V5.2, and tip and ring signaling.

Similarly, the home Mobility Node (605) transmits signals, dialed digits, or other information received from the LEC office (610) over port *b* to the mobile (630) using the appropriate RF protocols such as EIA-553, IS-54, IS-136, and IS-95. These protocols are well known in the art.

Mobility Node (607). This processing includes, for example, an announcement that the mobile is not within the region.

If the home Mobility Node (605) is connected to the visited Mobility Node (607) (step 275), the home Mobility Node (605) queries the visited Mobility Node (607) to determine the routing number (step 285). The routing number is a temporary directory number given to the mobile that associates the mobile, with an incoming call, to the visited Mobility Node (607). The home Mobility Node (605) then forwards the call to the visited Mobility Node (607) (step 290) via a direct connection to the PSTN (not shown) using the routing number. The visited Mobility Node (607) pages the mobile and connects the roaming mobile to the home Mobility Node (605) (step 295).

After the roaming mobile is connected to the home Mobility Node (step 295), the process continues to a modified active call process (step 800) illustrated in detail in FIG. 8. This process monitors the IS-41 protocol that connects the Mobility Nodes and maps it to the proper protocol to communicate with the LEC and the visited base station.

FIG. 8 illustrates a flowchart of the IS-41 active call process (process 800) used by the Mobility Node to make the wireless mobile appear as a wireline subscriber. In this process, the Mobility Node monitors its ports for a signal (step 801) from other Mobility Nodes. If a signal is not detected (step 805), the monitoring continues.

If the Mobility Node detects a signal (step 805), the Mobility Node then determines the signal type and source of the signal (step 810). If the signal is not detected by the home Mobility Node (step 815) it must have been detected by the visited Mobility Node. It is then determined if the signal came from the IS-41 link (step 850).

If the signal is from the IS-41 link, it is then determined if the signal has a cell site equivalent (step 855). If there is a cell site equivalent to the signal, the visited Mobility Node sends that equivalent signal to the cell site (step 865) in place of the original IS-41 signal. Possible signals that have cell site equivalents include an alert signal for the mobile or a disconnect signal. If the signal does not have a cell site equivalent, the visited Mobility Node processes the signal appropriately (step 875).

When the home Mobility Node (605) recognizes the origination from the mobile (630) over the cell (602), the home Mobility Node (605) then determines if the mobile (630) is one of the LEC office's subscribers (step 310) by sending a query that includes the mobile identification number to the HLR (606) (step 315).

The process then checks if the HLR (606) responded with a valid profile on the wireless subscriber (step 320). If the HLR (606) responds with a valid information profile, the Mobility Node (605) then performs its normal call setup tasks (step 335) that includes assigning the mobile (630) to an available channel on the cell. In the preferred embodiment, the call setup tasks are identical to those used by AMPS. Alternate embodiments use other call setup tasks. The Mobility Node (605) then connects the assigned channel to port *b* and originates a call on the port (step 340) using the directory number dialed by the mobile.

The LEC office (610) then performs its normal call setup tasks (step 385). The LEC office (610) recognizes the origination on port *b*, translates and routes the directory number, terminates the call on the wireline subscriber's telephone (625), and causes the wireline telephone (625) to ring by sending a ring signal to the telephone.

At this point, the mobile subscriber and the wireline subscriber are connected and the process continues with the active call process (step 700) illustrated in FIG. 7. If the wireline telephone answers the call or if the mobile subscriber invokes any special services or vertical features, the Mobility Node transmits the mobile's signals, dialed digits, or other information to the LEC office, using the appropriate LEC protocols, making the mobile appear as a wireline unit. These protocols include those well known in the art such as TR303, V5.2, and tip and ring signaling.

Similarly, the Mobility Node transmits signals, dialed digits, or other information received from the LEC office port *b* to the mobile using the appropriate RF protocols for that transaction. These protocols include IS-54, IS-136, and IS-95. As described above, the process illustrated in FIG. 7 describes in detail how the Mobility Node makes the mobile appear as a wireline unit.

If the HLR (606) does not respond with a valid profile on the wireless subscriber (step 320), the process determines if the mobile is roaming (step 325) in the service area. If the mobile (630) is not roaming, service access is denied (step 330) since the subscriber is neither a valid home system user nor a valid roamer. In

below a predetermined threshold (step 410), the cell (602) informs the Mobility Node (605) (step 415).

The Mobility Node (605) queries the surrounding cells to determine which cell is capable of communicating with the mobile (step 420). In this example, the nearby cell (601) is found to be able to support the mobile. The Mobility Node (605) allocates a channel on this cell (601) (step 425) and directs the mobile (630), through the current cell (602), to retune to the new channel (step 430).

The Mobility Node (605) then connects the new channel to port *b* of the LEC switch. Once the mobile (630) arrives on the new channel supported by the new cell (601), the old channel on the first cell (602) is deallocated (step 435).

This hand-off activity is completely transparent to the LEC office. Any services in effect in the LEC office are unaffected by this hand-off. The only difference the mobile subscriber might experience is the brief muting of the conversation that may occur during the hand-off using AMPS or TDMA technology.

The above described hand-off process is one of many embodiments. There are multiple sequences and triggers possible for alternate hand-off processes.

FIG. 5 illustrates a flowchart of a process in which a roaming, wireless mobile (630), illustrated in FIG. 6, registers in a visited system (603, 607, and 611). If the mobile roams outside the coverage area of the home Mobility Node (605) and any systems connected to the home Mobility Node, it no longer has access to its services in the LEC office.

The roaming mobile (630) first registers with the visited Mobility Node (607) (step 500). It is then determined if the visited Mobility Node (607) is coupled to the home Mobility Node (605) (step 505), either through an IS-41 line or other appropriate protocol interface.

If the visited Mobility Node (607) is coupled to the home Mobility Node (605), the home Mobility Node (605) is informed of the roaming mobile's location (step 510). This enables the home Mobility Node (605) to find the roaming mobile (630) in the event of a call termination from the home system.

If the home and visited Mobility Nodes (605 and 607) are coupled, a call received by the home LEC office (610) for the mobile is directed to the home Mobility Node (605) as normal. In this case, the home Mobility Node (605) is aware

Two systems are shown, the home system (901) and the visited system (905). The two systems are linked over the IS-41 link (910).

This embodiment illustrates the routing of a call, using the above described processes, from a wireline subscriber (915) to a wireless mobile (920) roaming away from the home system (901). The call from the wireline unit is routed through the PSTN to the wireless mobile's home system (901) in which the mobile is resident in the HLR (925). The home Mobility Node (930), knowing that the mobile (920) is roaming in another system, routes the call over the IS-41 link (910) to the visited system's Mobility Node (935). The visited Mobility Node (935) then performs the appropriate processes to route the call to the roaming mobile (920) through the appropriate base station (950).

In summary, the system and processes of the present invention provide wireless access to an existing LEC network throughout a metropolitan area. Unlike other wireless adjunct solutions, the present invention offers full mobility and direct access to wireline services throughout the metropolitan area and eliminates the infrastructure and signaling requirements associated with the Generic-C standards (i.e., AIN and ISDN).

The present invention is independent of access technology and RF spectrum. The present invention can use Advanced Mobile Phone Service (AMPS), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), Global System for Mobile communications (GSM) or any other access technology in any frequency band.

The present invention supports both stand-alone and networked applications allowing the LEC operators to customize the roaming options they offer to their subscriber base. These options can range from fixed wireless access to nation-wide and global roaming.

I CLAIM:

a Mobility Node coupled to the plurality of local exchange carrier switches, the plurality of cells, and a subscriber database, the Mobility Node comprising a processor that converts predetermined signals from the radiotelephone into local exchange carrier switch signals.

5. The system of claim 4 wherein the base station comprises a plurality of radios.

6. A method for handing-off a radiotelephone from a first cell to a second cell, both cells being in a wireless system comprised of a plurality of cells, the wireless system having a Mobility Node and a local exchange carrier switch, the local exchange carrier switch comprising a plurality of ports, the radiotelephone communicating radiotelephone signals with the cells, the method comprising the steps of:

the first cell monitoring a signal strength of the radiotelephone signals over a first communication channel;

informing the Mobility Node when the signal strength is less than a predetermined threshold;

the Mobility Node querying the plurality of cells for the second cell that is able to communicate with the radiotelephone;

the Mobility Node allocating a second communication channel in the second cell;

the Mobility Node directing the radiotelephone to tune to the second communication channel;

the Mobility Node connecting the second communication channel to a first port of the plurality of ports of the local exchange carrier switch; and

the Mobility Node deallocating the first communication channel.

7. A wireless access system that enables a local exchange carrier to provide wireless access to wireline services by a mobile radiotelephone, the system comprising:

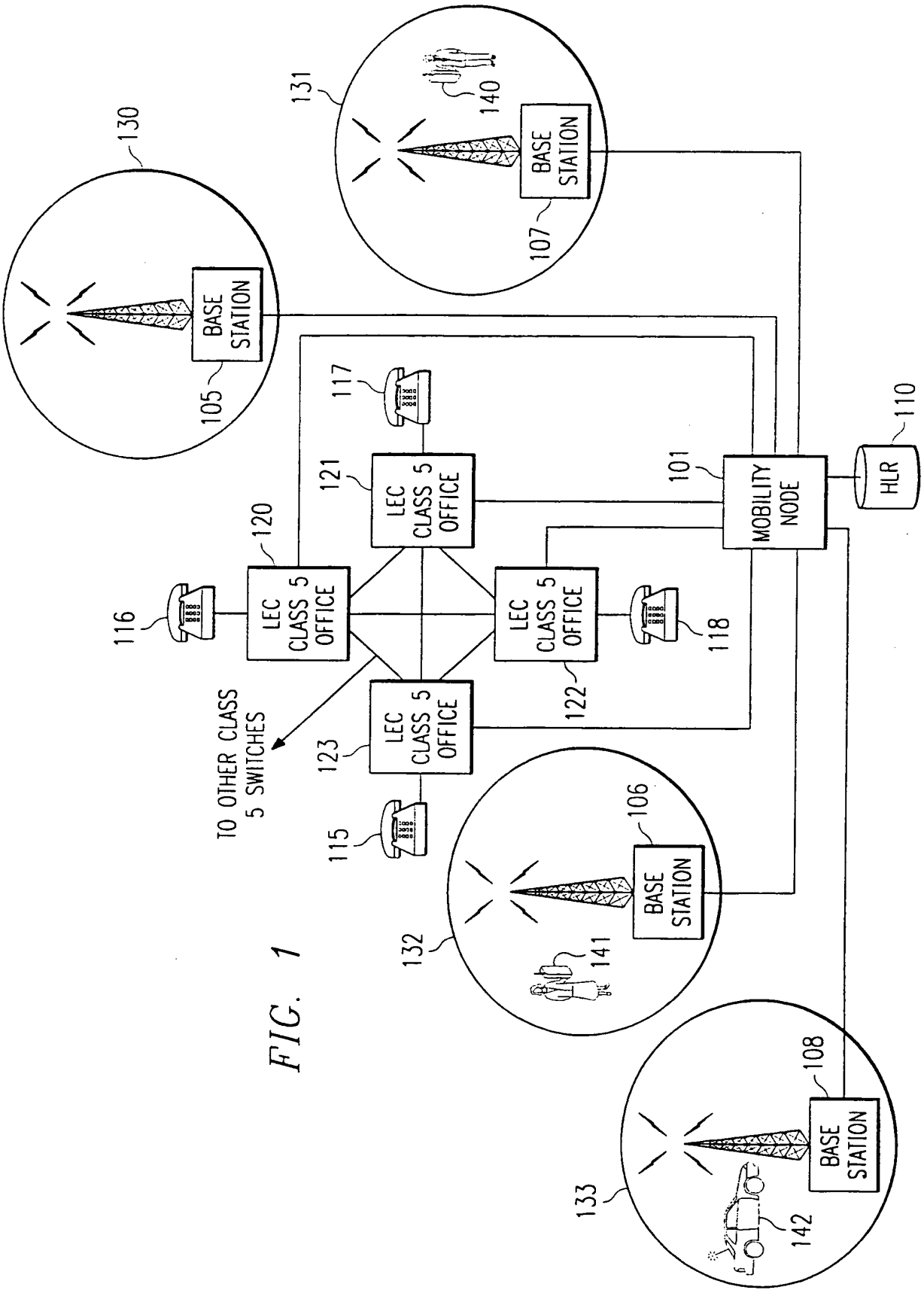
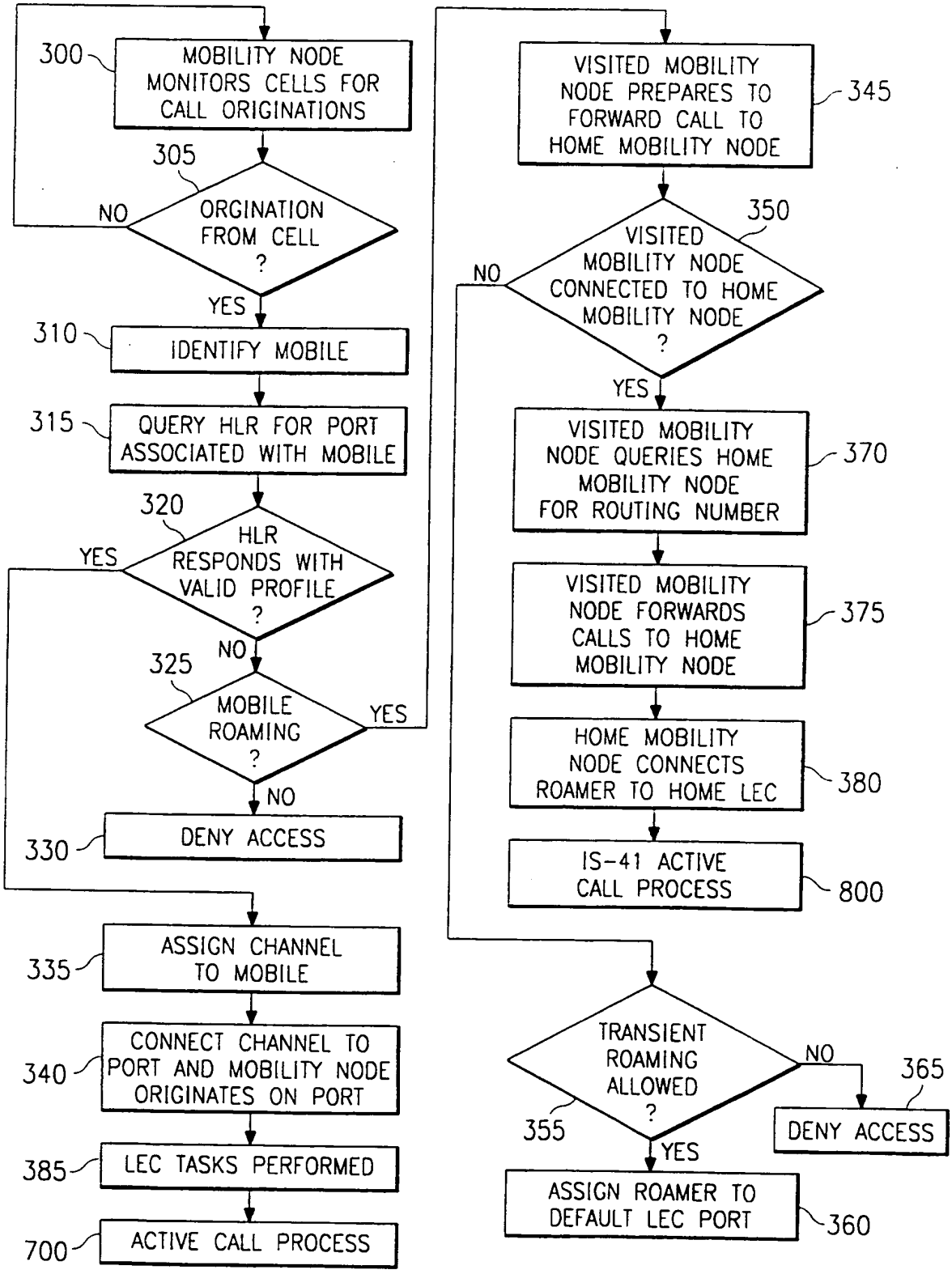


FIG. 1

FIG. 3



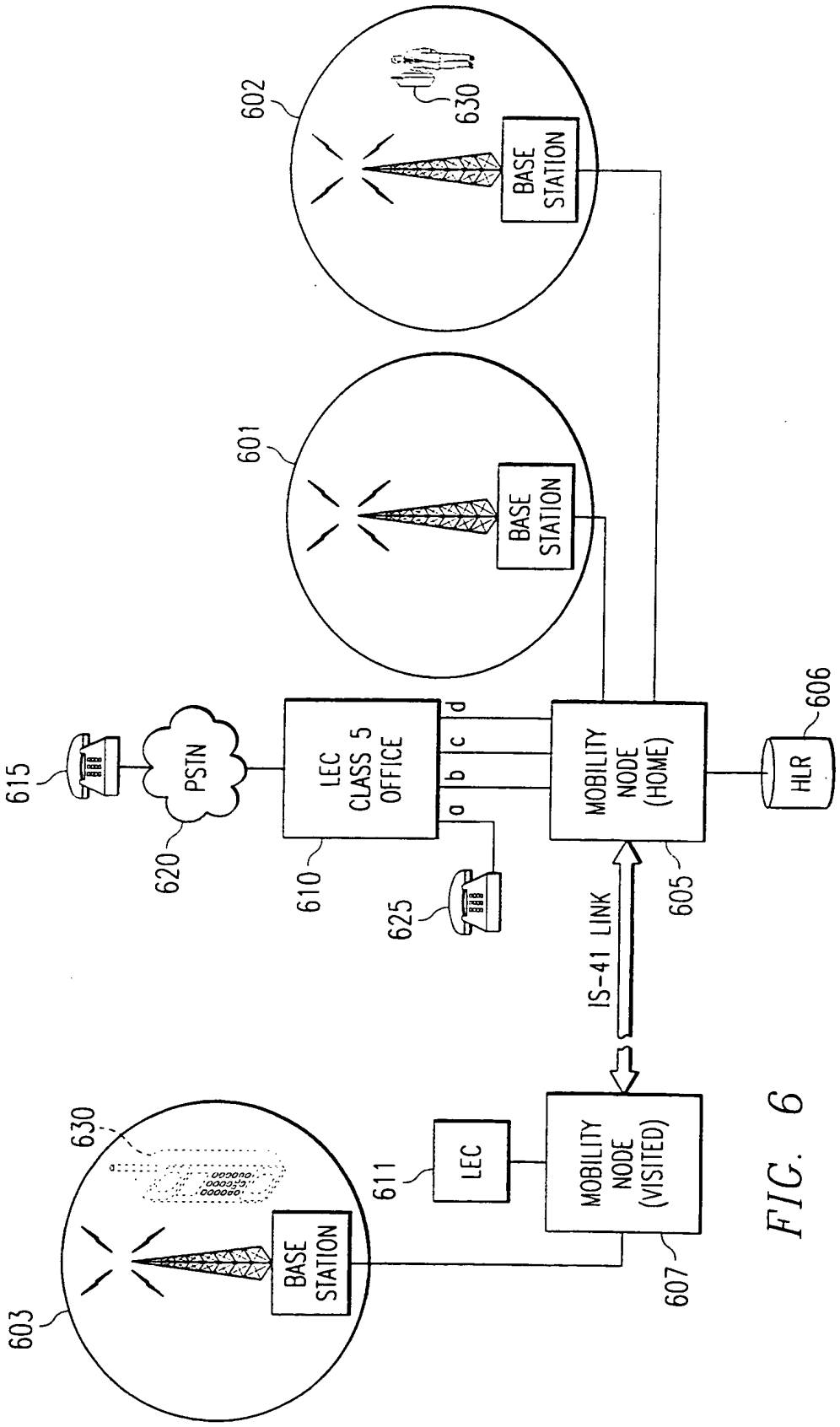


FIG. 6

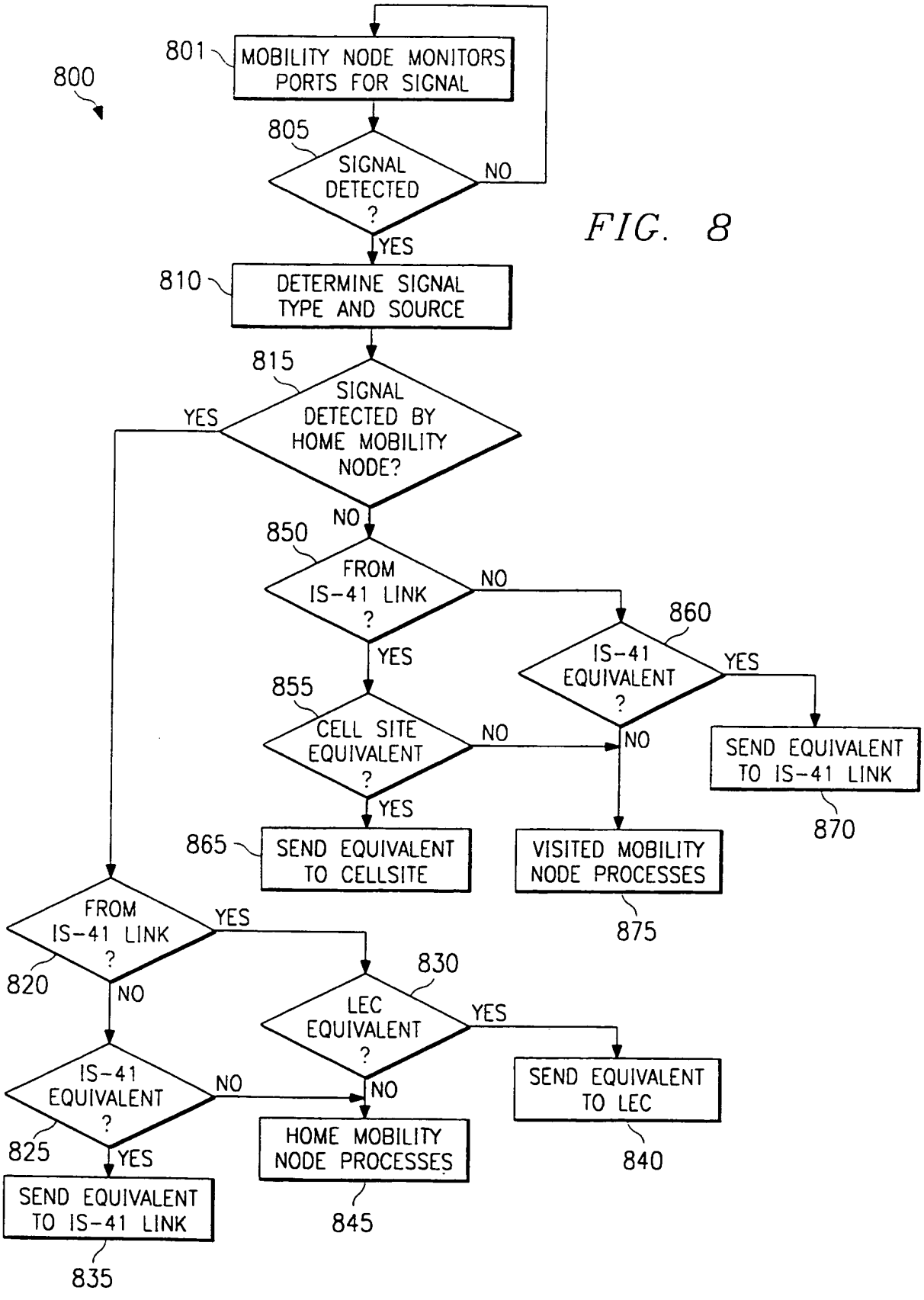


FIG. 8

INTERNATIONAL SEARCH REPORT

national Application No
PCT/US 98/11480

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q7/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X Y	WO 93 18606 A (BELL ATLANTIC NETWORK SERVICES) 16 September 1993 see page 22, line 32 - page 23, line 3 see page 23, line 28 - page 24, line 3 see page 26, line 28 - page 27, line 5 ---	1,2,4,7, 8 3,5
X	SIMON R: "SCHNURLOSE MEHRZELLENSYSTEME" TEC. DAS TECHNISCHE MAGAZIN VON ASCOM, no. 2, 1 January 1993, pages 20-26, XP000418751 see page 24, left-hand column, line 1 - right-hand column, line 54 see page 25, middle column, line 10 - right-hand column, line 50; figure 6 ---	6
Y	EP 0 596 727 A (NIPPON ELECTRIC CO) 11 May 1994 see abstract; figure 1 ---	3,5
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 October 1998	03/11/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schut, G

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

National Application No
PCT/US 98/11480

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9318606 A	16-09-1993	US 5353331 A	04-10-1994
		US 5469496 A	21-11-1995
		US 5579379 A	26-11-1996
		US 5506887 A	09-04-1996
		US 5664005 A	02-09-1997
		US 5610972 A	11-03-1997
		US 5758281 A	26-05-1998
EP 0596727 A	11-05-1994	JP 6152490 A	31-05-1994
		US 5430789 A	04-07-1995
EP 0589619 A	30-03-1994	CA 2099738 A	26-03-1994
		CN 1086075 A	27-04-1994
		FI 934206 A	26-03-1994
		JP 6209488 A	26-07-1994
		US 5655001 A	05-08-1997